

## **EUROPA GEOLOGY JIGSAW PUZZLE**

**Target Level:** Middle School

**Timetable:** Two 40-minute class periods

**Vocabulary:** crosscutting relationships, crust, geologic unit, mid-ocean ridge, plate tectonics, relative age, seafloor spreading, subduction zone, terrain

**Materials:** Each student will need two copies of C3 "Wedges" image, one printed on card stock; colored pencils; scissors

### **Introduction:**

Europa is a moon of Jupiter. Although its surface is frozen solid, there is the possibility that liquid water exists beneath the ice. Spacecraft pictures show areas of the surface where large plates of ice have broken apart and moved away from each other. Some have even twisted and rotated. The easiest way for these movements to occur is if the plates are floating on water, just like ice floes in the polar seas on Earth. If the plates can be fit back together like a jigsaw puzzle, with their edges matching up neatly, it will provide strong evidence that the material beneath them was once liquid, or at least a warm, slushy ice. Let's try it and see!

### **Procedure:**

#### **Part A:** Geologic Mapping

Look at Figure 1. Differences in surface texture, color or shading show us that particular regions are made of different materials, formed in unique ways, or created at different times. Making a geologic map is an easy way to show these differences. Using a copy of the "Wedges" image (Figure 1), identify three large areas of similar texture or shading. For now, avoid the small, narrow ridges. Lightly color each of the three surface types using a different color, even if they are not touching on the map (for example, color all smooth bright areas light green). When you are done, each color represents a different geologic unit.

#### **Part B:** Determining Relative Age

Now that you have made a geologic map of the area, can you figure out which unit is oldest and which is youngest? One way to determine relative age is to look for crosscutting relationships. Like a cake that is sliced, the surface can be broken by fractures or faults. The unit (or slice) which cuts through the rock (or cake) is always younger than the rock itself. In other words, you can't cut something unless it's already there! Using the color as the name for each geologic unit, arrange them in order of their relative age in the space below.

Oldest-----Youngest

## Part C: Reconstructing the Landscape

Now reconstruct the landscape to see how it looked at different times in the past. Using scissors, carefully cut up your map into the different geologic units. Each piece should contain one color only. When you are done, place the pieces back together in their correct position.

Look again at the relative age of each geologic unit on the "time line" above. Carefully remove those pieces that belong to the youngest unit. This will leave empty space behind. Can you fill the empty space by shifting together the remaining units? What kinds of "motion" did you have to use to do this? (e.g. transform = sliding past; divergent = moving apart; convergent = moving together; or rotation) Do any features or ridges match up now that were once separated by the youngest unit? The surface you have created represents Europa at some time in the past.

Remove the pieces for the next youngest unit and shift the remaining pieces to fill the gaps. What types of motion were required this time? Do any features or ridges match up again? Compare this "original landscape" to an uncut C3 "Wedges" image.

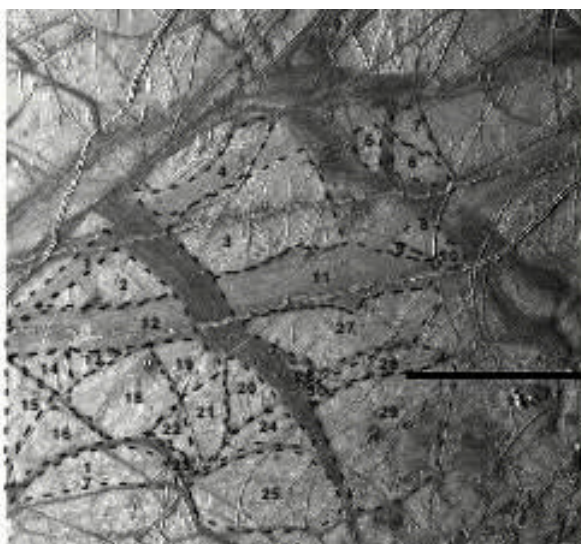
As a final step, reverse the process and "rebuild" the surface of Europa one unit at a time. This should give you an idea of the geologic history responsible for shaping Europa's icy surface.

### Review Questions:

1. List the types of motion used to reconstruct the "Wedges" landscape.
2. What does this suggest to you regarding the properties of the material beneath this region? (brittle, soft, fluid, solid, etc.)
3. Construct a simple graph showing the relationship between the brightness of each geologic unit and its relative age. What are some possible explanations for this relationship?
4. If a new geologic unit were to form in this region, would you predict it to be bright or dark?
5. Explain how the youngest geologic units you identified might have formed (i.e., where did the material come from?) Give the evidence for your answer.
6. If new ice or crust is being created in this region, and we find that the moon is not expanding or building mountains, what must be occurring elsewhere? Describe two ways in which this might occur.
7. Assuming that Europa's surface is no older than 100 million years old, as many scientists believe, calculate the minimum spreading rate for the dark wedge at left in the image. (Note: you will need to know that the image represents about 150 miles on each side)

**This full exercise including teacher notes are available on Web at - <http://www.jpl.nasa.gov/galileo/sepo>.**

Credit: This activity was adapted from the following source: Tufts, B.R., Greenberg, R., Sullivan, R., and Pappalardo, R., 1997, Reconstruction of European terrain in the Galileo C3 "Wedges" image and its geological implications, Lunar and Planetary Science Conference XXVIII Houston, Lunar and Planetary Institute, p. 1455-1456.



Teacher's key for figure 1 below:  
these outlines can be modified depending  
on grade level.

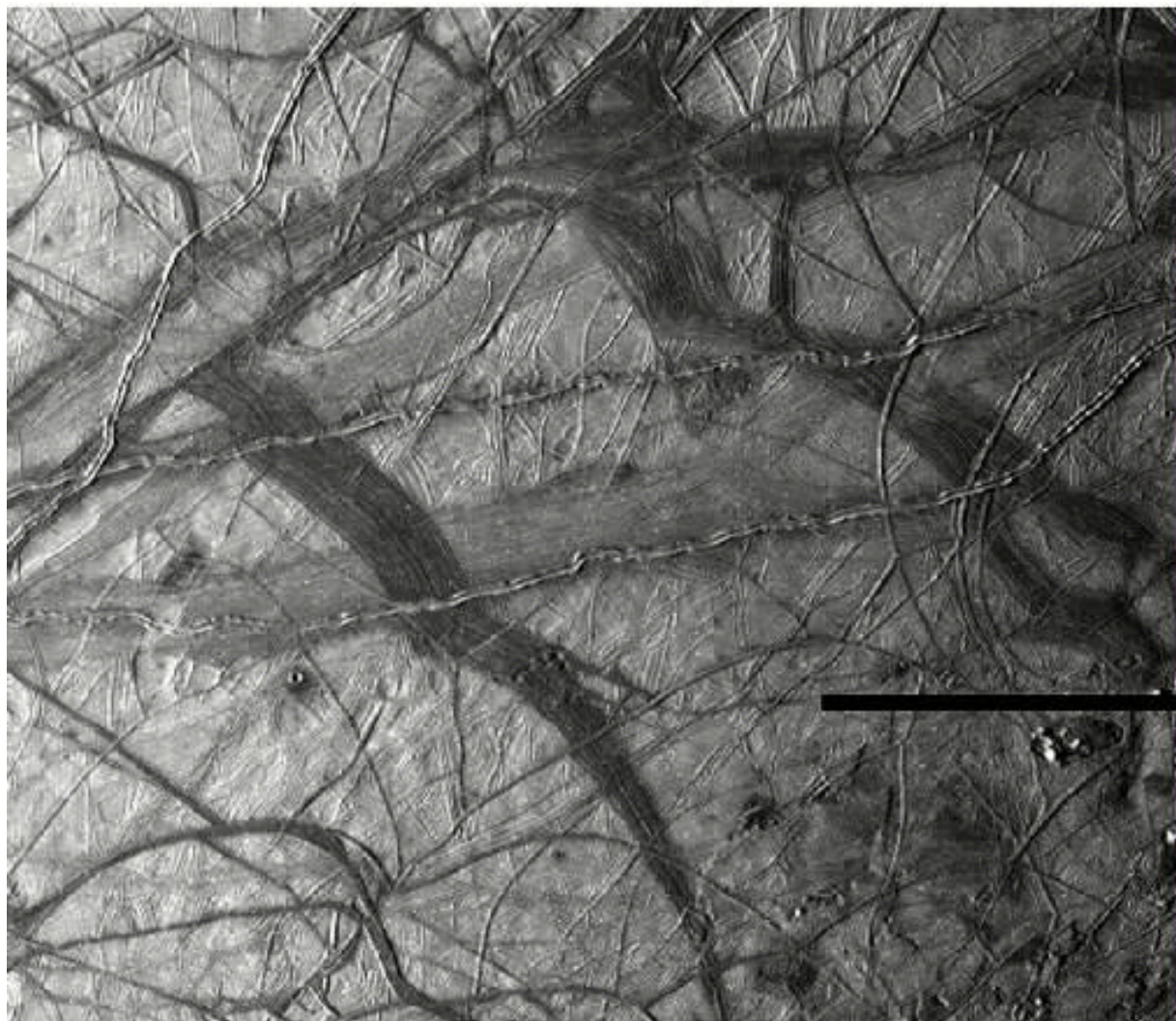


Figure 1. C3 Wedges. This is an image of the surface of Europa, a moon of Jupiter, taken by the Galileo spacecraft on its 3rd orbit around Jupiter.